THE DIMENSIONS OF PHYSICAL FITNESS— A FACTOR ANALYSIS OF SPEED, FLEXIBILITY, BALANCE, AND COORDINATION TESTS

by
EDWIN A. FLEISHMAN, PAUL THOMAS,
and PHILIP MUNROE

Technical Report 3

Prepared under Contract Nonr 609(32)
for the
Office of Naval Research

DEPARTMENT OF INDUSTRIAL ADMINISTRATION
AND DEPARTMENT OF PSYCHOLOGY
YALE UNIVERSITY
NEW HAVEN, CONN.

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This report describes the third in a series of studies under the general project title "The Development of Criteria of Physical Proficiency." This project is supported by funds provided under Contract Nonr 609(32) between Yale University and the Office of Naval Research.

Earlier reports have described the background and objectives of this program. The over-all objective is the identification of the components of physical proficiency and the development of appropriate tests to measure these components. The first report in this series, by Nicks and Fleishman, reviewed the literature on previous factor analytic research on the dimensions of physical fitness. The second report by Fleishman, Kremer, and Shoup, described the first large scale follow-up study conducted at the Great Lakes Naval Training Center. This study was an attempt to conceptualize the area of "strength" measurement and to provide recommendations for tests in this area. The present study is a parallel attempt to define the factors measured by tests emphasizing speed, flexibility, balance, and coordination.

This study is the product of the efforts of a great many people and it would be difficult to acknowledge all of them. Much of the initial conception and planning was done by the late Dr. Delmer C. Nicks. He not only conceived many of the original tests, but built and supervised their pretesting. Dr. Paul Thomas and Mr. Philip Munroe, of San Fernando Valley State College, Northridge, California, had worked with Dr. Nicks on this phase and continued with the study until its completion. They supervised the main data collection activity at the San Diego Naval Training Center, which was carried out during the Summer of 1959, and they contributed to later phases of the work.

At the San Diego Naval Training Center we are indebted to Captain R. E. Dornin, Commanding Officer, and to Commander F. M. Symons, Executive Officer, Recruit Training Command, for their assistance and support in this project. Valuable assistance

was also received from Lieutenant Commander Sumers, Training Officer, and Lieutenant Brawner, Training Operations Department; Ensign Bauer, Assignment Section; Ensign Stilwell, Physical Education Section; and Warrant Officer Tillery in the Supply Section. The twenty petty officers, temporarily assigned to our testing team, served admirably as test administrators. In addition to Dr. Thomas and Professor Munroe, Dr. Lou Young and Mr. Pete Cassidy of the San Fernando Valley State College, Department of Physical Education, provided valuable assistance in establishing and supervising the testing activity. Mr. George Marcinik constructed several of the tests used at San Diego.

The authors also acknowledge the expert statistical services provided by Dr. Benjamin Fruchter, University of Texas, and Dr. Andrew Comrey, University of California at Los Angeles. In addition, Mr. Elmar Kremer, Mr. Guy Shoup, and Mr. Gaylord Ellison provided tabulational and computational assistance during this period.

We also appreciate the vital assistance provided by Mrs. Carolyn Talalay, project secretary. James Malkin drew the fine illustrations for our test descriptions.

Appreciation for their continued support in connection with the contract is extended to Dr. Denzel D. Smith, former Head, Psychological Sciences Division, and to Dr. Glen Bryan, Head, and Mr. John Nagay, Assistant Head, Personnel and Training Research Branch, all in the Office of Naval Research. We also acknowledge the support of the Chief of Naval Personnel in facilitating the testing arrangements at San Diego.

Edwin A. Fleishman
Project Director

The Dimensions of Physical Fitness - A Factor Analysis of Speed, Flexibility, Balance, and Coordination Tests

What are the important factors which need to be assessed in any comprehensive evaluation of physical proficiency? The present study is another in a series (Hempel and Fleishman, 1955; Nicks and Fleishman, 1960; Fleishman, Kremer, and Shoup, 1961) concerned with this question.

The approach is a correlational approach. Tests are first selected or developed with certain hypothesized ability factors in mind. (For example, "rail walking" might be selected to measure a hypothesized factor of "balance.") A large number of such tests are administered to a large number of subjects. From the correlations among these performances, inferences are made about the common abilities needed to perform them. In other words, if the individuals who perform well on test 21 also perform well on test 28 (that is, there is a high correlation), then there must be some common requirement between these two tasks. Of course, with a large number of tests (e.g. thirty or forty) it becomes difficult to group tests according to common factors without mathematical assistance, but the principle is the same. The technique of factor analysis starts with the correlations among the tests and groups the tests in terms of a limited number of more "fundamental" group factors.

The last report (Fleishman, Kremer, and Shoup, 1961) applied the technique of factor analysis to the area of strength measurement. Thirty three tests, hypothesized to tap aspects of strength, were administered to 204 Navy recruits at the United States Naval Training Center, Great Lakes, Illinois. These tests included such diverse tasks as weight lifting, dynamometer tests, pull-ups, broadjump, softball throw, sit-ups, etc.) Five principle factors were found to account for performance on these 33 tests (for a description of these, see Fleishman, Kremer, and

Shoup, 1961). Furthermore, it was possible to specify the tests which best measured each factor.

The present study is an investigation of some skill areas which minimize strength but emphasize such features as speed, flexibility, balance, and possibly coordination. While considerable previous work had been done in the strength area, these other areas are not well defined. However, the review by Nicks and Fleishman (1960) indicated a number of factors identified by previous investigation in this area. The present study uses these tentative factors as a starting point. Most of the tests included here are new, designed specifically to tap hypothesized factors previously isolated but poorly defined in previous studies.

Some of the specific objectives of the study were 1) to explore the factor structure of the Speed-Flexibility-Balance area 2) to clarify the generality and limits of the factors which emerge 3) to discover which tests seem to provide the best assessment of each of the factors identified 4) to discover if a "coordination" factor emerges common to the more complex tests 5) to see if there is a speed factor general to all speeded tests 6) to see if flexibility and speed factors correspond to limbs or to specific muscle groups.

PROCEDURE

Hypothesized Factors and Test Descriptions

As a basis for test development nine factors were hypothesized from the results of the earlier review (Nicks and Fleishman, 1960). At least three tests were constructed around each factor. In order to allow the possibility of other factors, additional test variations were introduced. For example, tests of speed involving only arms or only legs were included to see if factors specific to limbs would emerge. Similarly, some balance tests involved open eyes, others involved closed eyes. The rationale will become clear in the following descriptions of factors and tests. We will describe an hypothesized factor and then describe the tests developed

around this factor; then proceed to the next factor. In all, thirty tests were developed.

FACTOR I - EXTENT FLEXIBILITY

This refers to the ability to extend or stretch the body or some part thereof as far as possible in various directions.

Test 1 - Abdominal Stretch. (Figure 1) This test proposed to measure how far the subject could hyper-extend his spine, or how far he could bend backwards. The subject stood with the front of his body against a fence. A strap was placed around the subject's buttocks and attached to the fence so that his hips were held firmly against the fence. The subject then leaned backwards as far as possible. His score was the horizontal distance from the fence to the subject's chin.

Test 2 - Toe Touching. (Figure 2) This test proposed to measure how far the subject could flex his spine forward; specifically, how far he could bend forward without bending his knees. The subject stood on a bench placing his toes even with the front edge. He bent over and reached down as far as possible with his hands while keeping his knees locked straight. A measuring scale was placed so that it extended 10 inches above and below the top of the bench. The subject's score was the distance on the scale he could touch and hold for two seconds. No bobbing was allowed.

Test 3 - Twist and Touch. (Figure 3) This test proposed to measure how far the subject could rotate his spine. The subject stood with his non-preferred side toward the wall, arms length away (with fist), with his feet together and his toes touching a line drawn perpendicular to the wall. A horizontal scale extended 12 inches on either side of a line on the wall drawn perpendicular to the line on the floor and was marked off from 0 inches to 30 inches. The subject kept his feet in place, twisted back around as far as possible and touched the wall with his preferred hand, keeping the hand at shoulder height with the palm facing the floor. The tester helped

the subject keep his feet in place by placing his own foot against the subject's foot. The subject's score was the farthest point on the scale reached and held for at least two seconds.

FACTOR II - DYNAMIC FLEXIBILITY

This refers to the ability to make repeated, rapid, movements which involve muscle flexibility.

Test 4 - Squat, Twist, and Touch. (Figure 4) This test proposed to measure the speed with which the subject could flex and extend his legs and rotate his spine. A belt was placed around the subject's arms, and was tightened just enough to hold the subject's elbows at the sides of his chest, yet permit him to bring his palms together in front of his body. The subject stood between uprights which were so placed that the subject could just touch either of the top tap plates (which were adjusted to the level of the subject's elbows) by rotating his body to one side or the other. Two other tap plates were placed on the uprights 18" below the top tap plates. On the signal "Go," the subject, standing upright, twisted to the right and touched the top tap plate with both hands, then squatted and touched the lower tap plate on his right with both hands. While in this squat position, the subject twisted to his left, touched the lower-left tap plate with both hands, and then rose and touched the top tap plate on his left with both hands. This completed one cycle. The subject's score was the number of cycles completed in 30 seconds.

Test 5 - Bend, Twist, and Touch. (Figure 5) This test proposed to measure the speed with which the subject could flex, extend and rotate his spine. The subject stood with his back to the wall and far enough from the wall so that he could bend over without hitting the wall with his buttocks. His feet were shoulder width apart. An "X" was placed on the wall in chalk or tape directly behind the middle of the subject's back and at shoulder height. Another "X" was made on the floor between the subject's feet. On the signal "GO," the subject bent forward and

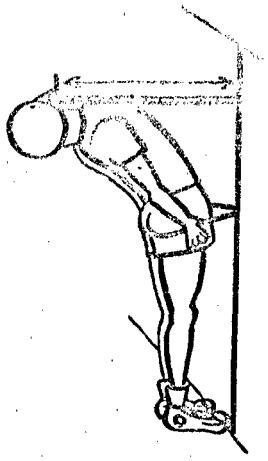

Figure 1. Abdominal stretch

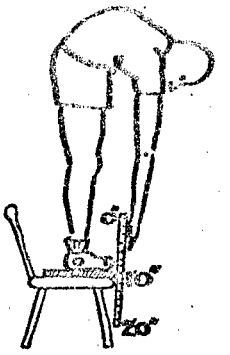

Figure 2. Toe touching

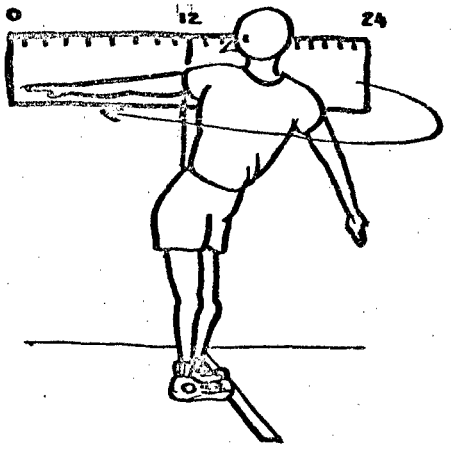

Figure 3. Twist and Touch

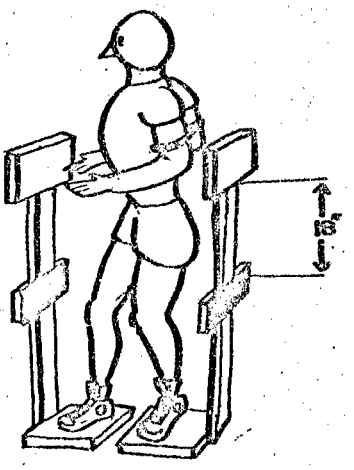

Figure 4. Squat, Twist, and Touch

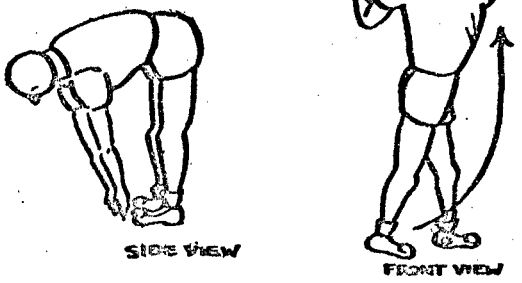

Figure 5. Bend, Twist, and Touch

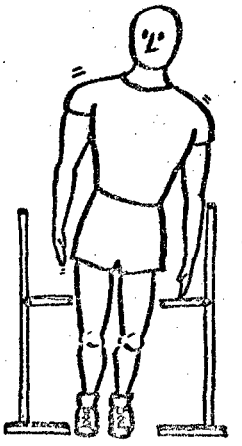

Figure 6. Lateral Bend

touched the X between his feet with both hands and then straightened up and touched the X on the wall with both hands. This represented one cycle. The next cycle was the same except that the subject twisted to his right and continued to alternate the side to which he twisted in each successive cycle. The subject's score was the number of cycles completed in 20 seconds.

Test 6 - Lateral Bend. (Figure 6) This test proposed to measure the speed with which the subject could flex laterally from side to side. The subject stood upright between two standards, arms straight and to his side with fingers pointed down. The tap plates were adjusted to 4 inches below the subject's fingertips. On the signal "GO," the subject bent to the right and touched the tap plate, then without twisting and with knees kept straight, he bent to the left and touched the plate on the left side. The lateral bending was done with knees and hips locked, shoulders back and head up. This completed one cycle. The subject's score was the number of cycles completed in 20 seconds.

FACTOR III - SPEED OF ARM MOVEMENT

This factor emphasized the speed with which simple arm movements could be made. These movements included circumduction, flexion, extension, horizontal abduction and adduction.

Test 7 - Plate Tapping. (Figure 7) This test proposed to measure the speed with which the subject could horizontally abduct and adduct his arm. The subject sat facing two 8 inch discs fastened to a board so that the distance between the discs was 24 inches. On the signal "GO," the subject, using his preferred hand, tapped the plate on his right, then immediately tapped the left plate. This was counted as one cycle. The subject's score was the number of cycles completed in 20 seconds.

Test 8 - Arm Circling. (Figure 8) This test proposed to measure the speed with which the subject could circumduct his arm. The subject, while standing, leaned over a waste basket and, using his preferred hand, swung his arm so that his hand

went completely around the circumference of the waste basket. The hand was kept below the top of the basket throughout the test. The subject's score was the number of revolutions made in 20 seconds.

Test 9 - Block Transfer. (Figure 9) This test proposed to measure the speed with which the subject could flex and extend his shoulder, and flex and extend his elbow. Two trays, 12 inches square, 9½ inches deep were placed on the table so that one tray was 6 inches beyond the first tray in front of the subject. Twelve one inch cube blocks were in the tray nearest the subject. On the signal "GO," the subject, using his preferred hand, transferred all the blocks from the front tray to the far tray, taking only one block at a time. The subject then transferred the blocks back to the near tray, and then repeated this procedure to the far tray so the blocks had been transferred 3 times, ending up in the far tray. The subject's score was the number of seconds required to complete the three transfers.

FACTOR IV - SPEED OF LEG MOVEMENT

This factor referred to the speed with which leg movements could be made. These movements included circumduction, flexion, extension, horizontal abduction and adduction.

Test 10 - One Foot Tapping. (Figure 10) This test proposed to measure the speed with which the subject could horizontally abduct and adduct his leg. The subject sat on a chair, placing his preferred foot next to a board 18 inches long. A 6 inch perpendicular partition was in the center of the board. On the signal "GO," the subject lifted his foot over the partition and tapped the board on the other side. Then, he immediately lifted and returned his foot over the partition and tapped the board on the starting side. This was counted as one cycle. The subject's score was the number of cycles completed in 20 seconds.

Test 11 - Two Foot Tapping. (Figure 11) This test proposed to measure the speed with which the subject could flex and extend his hip joint. The subject stood

Figure 7. Plate Tapping

Figure 8. Arm Circling

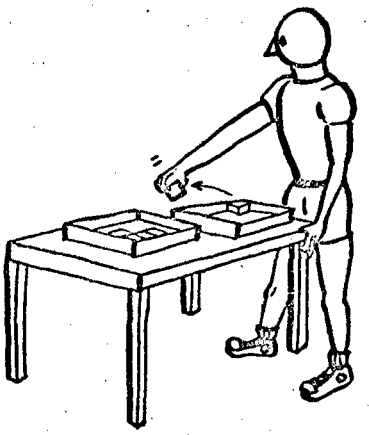

Figure 9. Block Transfer

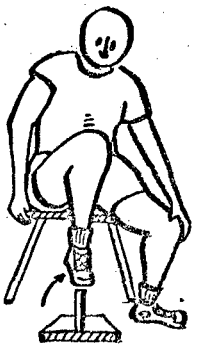

Figure 10. One foot Tapping

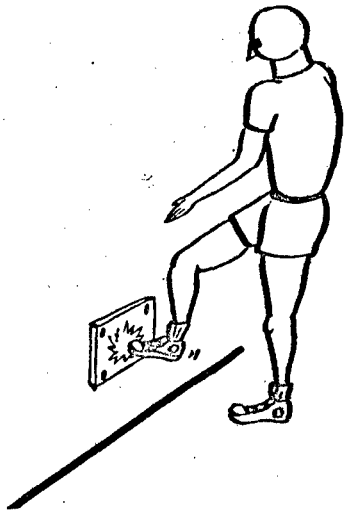

Figure 11. Two foot Tapping

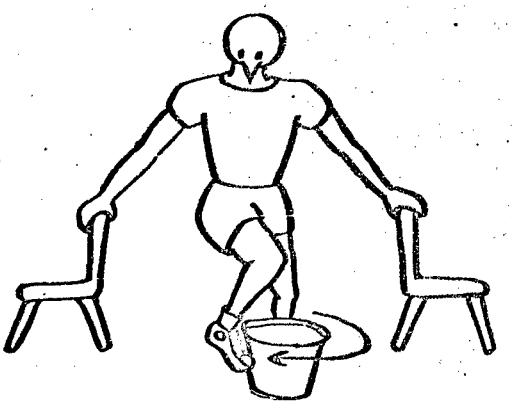

Figure 12. Leg Circling

facing a 12 inch square kick board attached to a wall 18 inches above the floor. On the signal "GO," the subject lifted his right foot and tapped the kick board twice before returning it to the ground. He then did the same with his left foot. Two distinct taps were made with each foot each time and these four taps made one complete cycle. The score was the number of cycles completed in 15 seconds.

Test 12 - Leg Circling. (Figure 12) This test proposed to measure the speed with which the subject could circumduct his leg. The subject stood in such a way that he could swing his preferred leg around the circumference of a waste basket in a clockwise direction. He used the back of two chairs for support, and kept his foot below the level of the waste basket throughout the test. The subject's score was the number of revolutions completed in 15 seconds.

FACTOR V - SPEED OF CHANGE OF DIRECTION

This factor emphasizes the ability of the subject to change the direction of movement of the body, or parts thereof, either abruptly or in a continuous fashion.

Test 13 - Dodge Run. (Figure 13) This test proposed to measure the ability to change direction laterally while moving the body forward. Six chairs are set up as shown in Figure 13. On the signal "GO," the subject ran around the chairs in the path shown on the diagram. Upon arriving at chair number six the subject did not go back to the starting line, but went directly around chair number one again and repeated the path around all of the chairs. When he arrived at chair six the second time, he went directly to the starting line. The subject's score was the length of time required to make the two trips and return to the starting line.

Test 14 - Shuttle Run. (Figure 14) This test proposed to measure the speed with which the subject could abruptly and completely change his direction of body movement. Two parallel lines 15 feet apart were made on the floor. The subject stood behind one line and on the signal "GO," ran to and across the other line, stopped, turned and ran back across the first line. Both feet had to cross the line each

time. This completed one round trip. The subject's score was the length of time required to make five round trips.

Test 15 - Circle Run. (Figure 15) This test proposed to measure the speed with which the subject could change his direction of body movement continuously. A circle 12 feet in diameter was made on the floor. A starting point was marked on the circumference of the circle. On the signal "GO," the subject ran clockwise around the outside of the circle. When he returned to the starting point he had completed one round. The subject's score was the length of time required to complete five rounds.

FACTOR VI - COORDINATION

This factor refers to the ability of the subject to perform a number of complex motor movements simultaneously.

Test 16 - Figure-8 Duck. (Figure 16) This test proposed to measure the ability of the subject to alter his body position while moving forward rapidly. Two uprights were placed 10 feet apart with the cross bar adjusted to the height of the subject's waist. The subject started at the right of one of the uprights. On the signal "GO," he ran under the cross bar, went around the far upright, back under the cross bar again, and around the near upright. In other words, the subject ran around the uprights in a figure-8 fashion, ducking under the cross bar each time. This completed one cycle. The subject's score was the length of time required to complete four cycles.

Test 17 - Grass Drill. (Figure 17) This test proposed to measure the ability of the subject to make fast total body movements while on all fours. Two chairs were placed seven feet apart. The subject got down on all fours, hands and feet, beside one of the chairs. On the signal "GO," the subject, on all fours, travelled around the first chair, between the chairs, around the second chair, and back between the

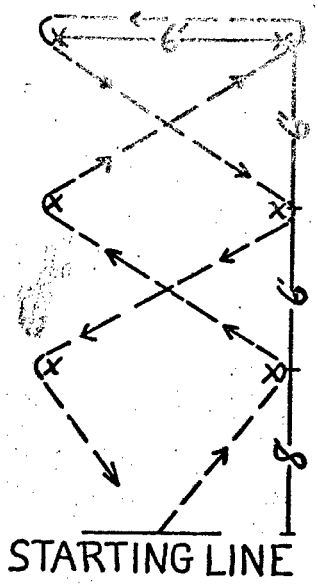

Figure 13. Testing Arrangement for Dodge Run and Soccer Dribble

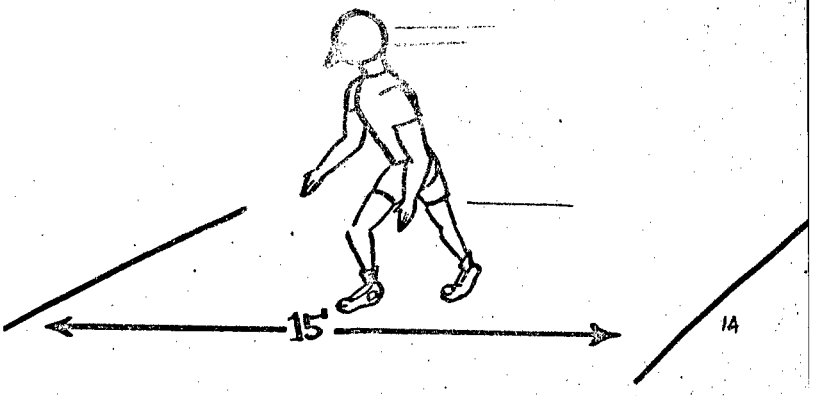

Figure 14. Shuttle Run

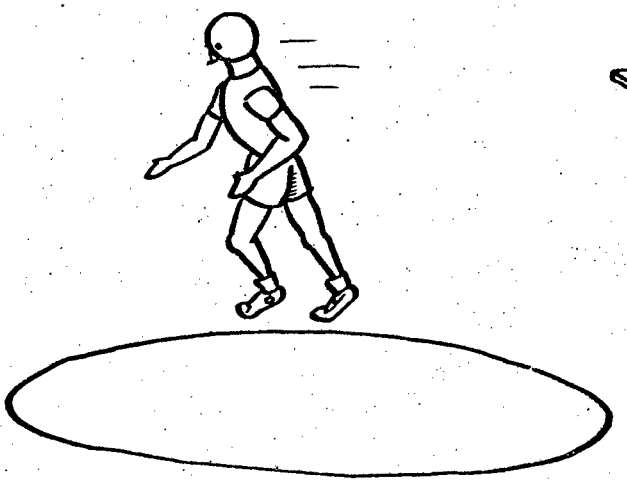

Figure 15. Circle Run

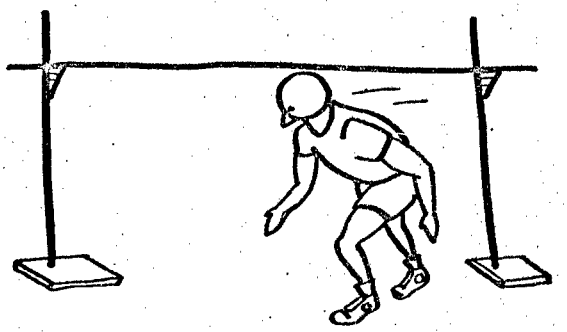

Figure 16. Figure-8 Duck

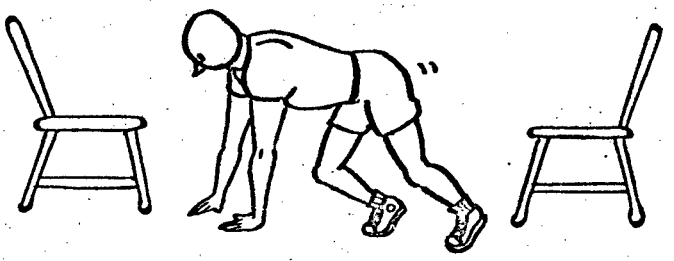

Figure 17. Grass Drill

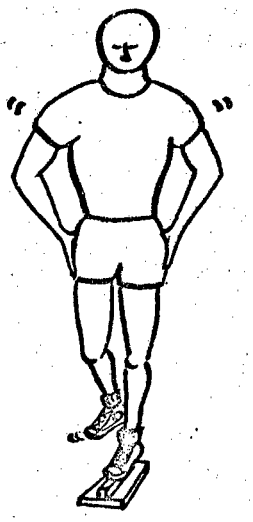

Figure 18. One Foot Lengthwise Balance

chairs to his starting point, thus completing the figure-8. This completed one cycle. The subject's score was the length of time required to complete four cycles.

Test 18 - Soccer Dribble. (Figure 13) This test proposed to measure the ability of the subject to manipulate an object with his feet while moving rapidly. On the signal "GO," the subject dribbled the soccer ball with his feet around the chairs on the path shown in the diagram. Upon reaching chair six he returned directly to the starting line. The subject's score was the length of time required to dribble around the chairs and return to the starting line.

FACTOR VII - STATIC BALANCE

This factor refers to the ability of the subject to maintain bodily equilibrium with his eyes either open or closed.

Test 19 - One Foot Lengthwise Balance - Eyes Open. (Figure 18) A wood balance rail 1½ inches high, 3/4 inch wide, and 24 inches long was fastened to a board as shown in Figure 18. The subject balanced on the rail, with his hands on his hips, using the preferred foot with the long axis of the rail parallel to the long axis of his foot. The subject determined the starting signal. When he felt he had his balance he said "GO," and the tester started a stop watch. The time ended when the subject touched the floor with any part of his body, or when he removed either hand from his hips. The subject's score was the length of time he held his balance.

Test 20 - One Foot Lengthwise Balance - Eyes Closed. This was the same as Test 19 except that the eyes were kept closed throughout.

Test 21 - One Foot Cross Balance - Eyes Open. (Figure 19) This was similar to Test 19 except that the subject balanced on the ball of the preferred foot with the long axis of the rail perpendicular to the long axis of the foot. Particular attention had to be given to the balancing foot since it was easy to let the heel or toe touch the floor unintentionally.

Test 22 - One Foot Cross Balance - Eyes Closed. This was the same as Test 21 except that the eyes were kept closed throughout.

Test 23 - Two Foot Lengthwise Balance - Eyes Open. (Figure 20) This was similar to Test 19 except that two feet were used on the balance rail and these had to maintain contact with the rail throughout.

Test 24 - Two Foot Lengthwise Balance - Eyes Closed. This was the same as Test 23 except that the eyes were kept closed throughout.

Test 25 - Two Foot Cross Balance - Eyes Open. (Figure 21) This was similar to Test 21 except that two feet were used on the rail and had to maintain contact with it throughout.

Test 26 - Two Foot Cross Balance - Eyes Closed. This was the same as Test 25 except that the eyes were kept closed throughout.

FACTOR VIII - PERFORMANCE BALANCE

This factor refers to the ability of the subject to maintain his total body balance while in motion.

Test 27 - Rail Walking. (Figure 22) This test proposed to measure the ability of the subject to maintain his balance while moving backward on a very narrow support. A hexagonal rail was constructed of 6 boards, 3/4 inch wide, 3½ inches deep, and 24 inches long, fastened so that they formed a rigid equilateral hexagon. The subject walked backwards on the rail stepping on each segment in succession, touching only one segment at a time with each foot, (i.e., the foot was not allowed to overlap two segments). The long axis of the foot was kept parallel with the long axis of the segment. The subject's score was the number of segments traversed before he lost his balance and stepped off the rail or before he violated any of the above directions.

Test 28 - Board Balance. (Figure 23) This test proposed to measure the ability of the subject to maintain his balance while standing on a movable support. A teeter

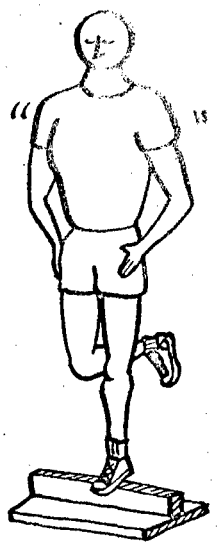

Figure 19. One Foot Cross Balance

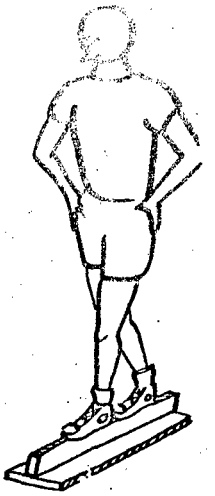

Figure 20. Two Foot Lengthwise Balance

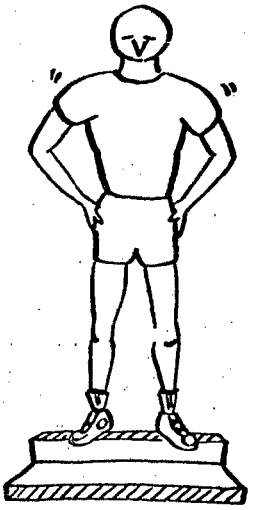

Figure 21. Two Foot Cross Balance

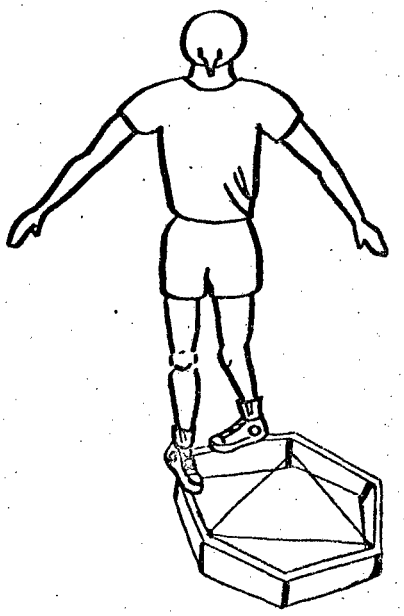

Figure 22. Rail Walking

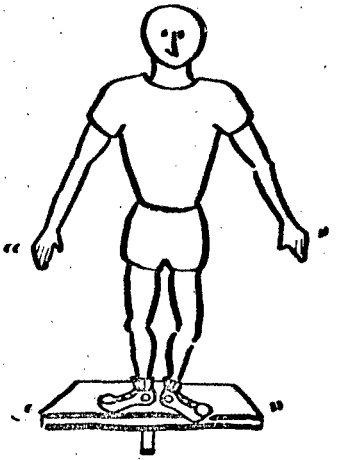

Figure 23. Board Balance

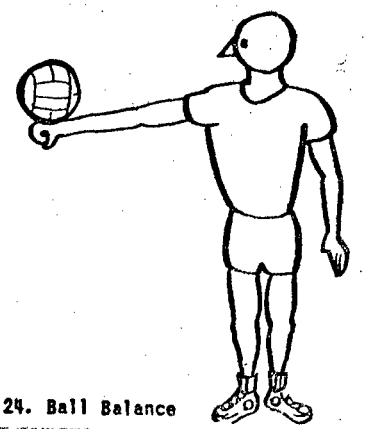

Figure 24. Ball Balance

board was constructed of a board, 24 inches x 12 inches x 1 inch, supported in the middle by a board, 12 inches x 2 inches x 4 inches. The bottom of this 12 x 2 x 4 center board had the edges planed off at an angle so that the width of surface in contact with the floor was only one inch (see Figure 23). The subject balanced himself on the teeter board by placing one hand on the tester's shoulder for support. When the subject felt he had his balance and wanted to start, he removed his hand from the tester's shoulder. This was the signal for the tester to start the stop watch. The subject's score was the length of time he maintained his balance. His balance was lost when he fell off the board, or when either end of the teeter board touched the floor.

FACTOR IX - BALANCING OBJECTS

This factor emphasizes the ability of the subject to balance objects with his hands or fingers while standing still.

Test 29 - Stick Balance. This test proposed to measure the ability of the subject to balance an unstable object with the non-preferred hand. Keeping his feet stationary, the subject balanced a stick of wood, 3/4 inch x 3/4 inch x 12 inches, on the index finger of his non-preferred hand. The subject determined his starting time by saying "GO," when he felt he had the stick balanced under control. His time ended when the stick touched any other part of his body, when the stick touched the floor, or when the subject moved either foot. The subject's score was the length of time he balanced the stick.

Test 30 - Ball Balance. (Figure 24) This test required the subject to balance a ball on his extended arm. The subject, keeping his feet stationary, balanced a volley ball on the back of the closed fist of his preferred hand, holding his arm at shoulder height. The subject determined his starting time by saying "GO," when he felt he had the ball under control. His time ended when he let the ball touch any other part of his body, when the ball fell to the floor, or when he moved

either foot. The ball had to be kept on the back of the fist and was not allowed to touch the wrist or arm. The wrist was held straight and was not allowed to bend to help support the ball. His score was the length of time he balanced the ball.

Pretesting and Pilot Study

The tests just described, are a product of considerable pre-testing, modification, and standardization. Actually, a much larger variety of tests was tried out, but found deficient for a number of reasons, (e.g. difficulty of administration and standardization, lack of reliability, lack of discrimination among individuals in the relevant age group, equipment construction problems, etc.).

After these 30 tests were selected and standardized they were combined into a battery and administered to groups of students at San Fernando Valley State College. As a result of this pilot study certain minor refinements and changes were made in the tests themselves (e.g. time limits, number of repetitions) and in the order of administration. The administration order developed is presented in Figure 25. Factors which determined this order include joint considerations of 1) fatigue effects (e.g. tests involving total body exertion, such as Dodge Run and Circle Run were separated by less strenuous tests, such as Balance), 2) traffic flow from testing station to testing station when large groups were run through, and 3) the number of test administrators available.

Administration of the Main Study at San Diego

A testing team was established at the U. S. Naval Training Center, San Diego, California. This team included four professional physical educators. They in turn, were assisted by twenty Chief Petty Officers assigned to us for the purpose of this study. The team spent half a day training these Chief Petty Officers in the administration of the tests. Another pilot group of 55 Navy recruits were run through the complete test battery, before the main testing program began. The results of this first day of testing were used only to smooth out the testing procedures, to

improve the performance of the program, and to give additional training to the test administrators. In the main study, the complete battery was administered to an additional 204 Navy recruit subjects.

These tests were conducted on a smooth, black-topped physical training area, on an adjacent grass field, and in enclosed handball courts. The weather was mild and pleasant with temperatures in the 70's. The boys wore their physical training uniform, consisting of T-shirts, pants, and their regular issue boots. The boots probably hindered the boys in some of the tests, but all of the boys wore them; so they were all affected. Throughout the program, every effort was made to obtain each boy's best performance. The boys were given considerable instruction and warm-up. They were allowed several attempts in order to get the best score. The testers gave the boys all the encouragement they could.

The boys were divided into four groups (A, B, C, D) and sent through in four lines. Group A went to Station 1A, then 2A, 3A, etc. Group B started at Station 1B and proceeded to 2B, 3B, and so on. Groups C and D went to the stations in their respective lines. There were five testers assigned to each line. The testers at Station 1, when the whole group had passed them, went to Station 6, then to stations 11, 16, etc. The testers at Station 2 went to stations 7, 12, and so on. The lines flowed smoothly so that there was little waiting at any station, except for the balance tests, which took a little longer. The time taken to test a company of 60 boys was approximately two hours. The 204 boys were tested in four half-day periods.

One physical education supervisor was in charge of each line. They helped out where needed and kept things orderly and organized. Each boy had his own score card with him, which he carried from station to station and turned in at the end. This card is shown in Figure 25. All scores were recorded to the nearest half inch in the distance tests or to the nearest tenth of a second in the timed tests.

PHYSICAL FITNESS PROJECT II

1. Sign in table (see back of page)
2. Height and weight (see back of page)
3. Plate tapping _____ times
4. Dodge run _____ seconds
5. Block transfer _____ seconds
6. Abdominal stretch _____ inches
7. Lateral bend _____ times
8. Toe touching _____ inches
9. Shuttle run _____ seconds
10. Two-foot lengthwise balance--eyes open _____
    --eyes closed _____
11. Two-foot cross balance--eyes open _____
    --eyes closed _____
12. Ball balance _____ seconds
13. Squat, twist, touch _____ times
14. Arm circling _____ times
15. Sprint 40 yards _____ seconds
16. Twist & turn _____ inches
17. One foot tapping _____ times
18. Bend, twist, and touch _____ times
19. Two foot tapping _____ times
20. Grass drill _____ seconds
21. Rail walking _____ segments
22. One-foot lengthwise balance--eyes open _____
    --eyes closed _____
23. One-foot cross balance--eyes open _____
    --eyes closed _____
24. Stick balance _____ seconds
25. Board balance _____ seconds
26. Circle run _____ seconds
27. Leg circling _____ times
28. Figure - 8 duck _____ seconds

NAME _____ SERVICE NUMBER _____

SIDE ONE

PHYSICAL FITNESS PROJECT II

NAME _____ SERVICE NO. _____ COMPANY _____

HOMETOWN _____

AGE _____ yrs. mos. HEIGHT _____ inches WEIGHT _____ lbs.

Athletic background

List the sports in which you have participated in high school and in college on a varsity, junior varsity, or freshman level. Signify by writing "V" for varsity, "JV" for junior varsity, and "F" for freshman after the sport. Also write "FS" if you played first string, or "S" if you were a substitute. Example--Basketball (JV) (FS) means that the subject played junior varsity basketball on the first string.

HIGH SCHOOL	COLLEGE

Check the estimated size of your high school and college.

High School	College
_____ 0 - 100	_____ 0 - 400
_____ 100 - 400	_____ 500 - 1000
_____ 400 - 800	_____ 1000 - 2000
_____ over 800	_____ over 2000

Location of High School _____

Location of College _____

SIDE TWO

Figure 25. Subject Score Card

RESULTS

Distribution Statistics

Table 1 presents the means and standard deviations for all tests administered at San Diego. Complete frequency distributions were tabulated for each test. For practically all the tests these closely approximated normal distributions. The average age of our subjects was 18 years, 6 months (Standard Deviation = 1 year, 5 months). Their average height was 5 feet, 9½ inches (Standard Deviation = 2.4 inches) and their average weight was 153.7 pounds (Standard Deviation = 18.0).

Test Intercorrelations

Table 2 presents the matrix of correlations among the 30 tests. It can be seen that there is no general "athletic proficiency" factor, since the correlations are not uniformally high. Rather, there are groupings of correlations, indicating a number of separate factors.

Factor Analysis

The correlation matrix was factored by the Thurstone Centroid Method (Thurstone, 1947). The six factor centroid solution is presented in Table 3. Rotation to simple structure was accomplished using Kaiser's Verimax analytical solution programmed for an IBM 650 computer. The resulting rotated matrix is presented in Table 4. The factors were then interpreted for meaningfulness from the loadings of the tests. We will describe each factor, in turn. Tests with loadings of .30 or over are listed for each factor.

Factor I is best defined by the speed tests involving running or gross body

Test	Name	Loading
13	Dodge Run	.69
16	Figure-8 Duck	.68
14	Shuttle Run	.63
17	Grass Drill	.62
18	Circle Run	.59
11	Arm Circling	.52
7	Plate Tapping	.39

propulsion. The tests originally included to measure Speed of Change of Direction are on this factor. However, Circle Run does not emphasize this requirement. The

TABLE 1

Means and Standard Deviations of Test Scores

(N = 204)

	Tests	Units*	Mean	S.D.**
1.	Abdominal Stretch	inches	29.49	2.62
2.	Toe Touch	"	11.65	2.59
3.	Twist and Touch	"	18.51	5.28
4.	Squat, Twist and Touch	cycles	18.05	2.63
5.	Bend, Twist and Touch	"	15.14	1.84
6.	Lateral Bend	"	33.73	5.83
7.	Plate Tapping	"	44.08	5.33
8.	Arm Circling	"	52.18	7.61
9.	Block Transfer	seconds	24.06	2.85
10.	One Foot Tapping	cycles	27.98	2.86
11.	Two Foot Tapping	"	10.69	1.70
12.	Leg Circling	"	20.53	2.62
13.	Dodge Run	seconds	16.26	1.12
14.	Shuttle Run	"	19.24	1.29
15.	Circle Run	"	18.68	1.23
16.	Figure-8 Duck	"	18.61	1.64
17.	Grass Drill	"	22.28	3.29
18.	Soccer Dribble	"	18.72	2.80
19.	1-Ft. Lngth. Bal. Eyes Op.	"	55.73	47.69
20.	1-Ft. Lngth. Bal. Eyes Cl.	"	5.31	4.84
21.	1-Ft. Cross. Bal. Eyes Op.	"	35.20	35.31
22.	1-Ft. Cross Bal. Eyes Cl.	"	3.74	2.18
23.	2-Ft. Cross Bal. Eyes Op.	"	21.40	30.29
24.	2-Ft. Cross Bal. Eyes Cl.	"	3.30	1.54
25.	2-Ft. Lngth. Bal. Eyes Op.	"	11.93	16.23
26.	2-Ft. Lngth. Bal. Eyes Cl.	"	2.65	1.62
27.	Rail Walking	segments	15.34	14.96
28.	Board Balance	seconds	4.90	3.95
29.	Stick Balance	"	7.61	7.54
30.	Ball Balance	"	19.38	39.70

* See test descriptions for scoring procedures.

** The distributions were generally symmetrical except for several of the Balance tests which were positively skewed.

Table 1

Correlations* Among the Test Scores

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Abdominal Stretch		31	26	09	13	10	-05	10	-04	08	13	-04	-04	09	02	11	05	-02	09	10	01	02	-00	07	-02	-04	-05	09	13	13
2. Toe Touch	31		13	06	17	12	10	22	02	26	16	24	13	25	15	22	31	06	09	-01	10	17	04	-00	03	08	10	09	05	10
3. Twist and Touch	26	13		10	07	20	-23	-08	-06	05	14	-04	03	02	11	03	00	04	06	-02	-07	-09	-01	-07	05	-09	06	-07	09	05
4. Squat, Twist, Touch	09	06	10		45	36	25	32	28	36	33	28	17	26	22	24	17	18	-03	-02	03	06	11	15	11	03	12	19	06	08
5. Bend, Twist, Touch	13	17	07	45		33	29	27	32	27	15	18	20	30	19	26	13	25	15	04	13	14	11	12	10	11	12	22	13	04
6. Lateral Bend	10	12	20	36	33		12	14	39	34	11	22	04	18	22	18	18	14	11	-01	01	15	01	-03	09	09	21	18	02	-01
7. Plate Tapping	-05	10	-23	25	29	12		45	36	19	32	26	37	34	13	32	14	15	05	12	15	26	18	14	06	17	13	15	06	10
8. Arm Circling	10	22	-08	32	27	14	45		20	19	25	23	43	41	26	37	34	14	01	01	05	16	08	08	07	13	-01	17	12	13
9. Block Transfer	-04	02	-06	28	32	39	36	20		31	11	29	20	23	18	21	09	27	18	03	05	18	09	05	05	06	11	25	15	03
10. One Foot Tapping	08	26	05	36	27	34	19	19	31		29	50	11	25	23	24	25	18	25	-00	18	21	08	04	13	19	22	23	05	04
11. Two Foot Tapping	13	16	14	33	15	11	32	25	11	29		22	07	20	04	17	17	08	22	09	16	07	13	09	15	17	09	16	10	13
12. Leg Circling	-04	24	-04	28	18	22	26	23	29	50	22		14	23	30	35	30	19	19	-01	26	17	10	-01	13	16	23	29	13	07
13. Dodge Run	-04	13	03	17	20	04	37	43	20	11	07	14		46	45	46	36	20	04	-01	06	04	10	06	-04	04	07	-00	-03	-03
14. Shuttle Run	09	25	02	26	30	18	34	41	23	25	20	23	46		45	47	39	19	06	-04	14	13	03	-06	-05	20	09	17	10	13
15. Circle Run	02	15	11	22	19	22	13	26	18	23	04	30	45	45		46	47	30	11	02	11	19	04	-01	02	03	12	14	-03	-07
16. Figure-8 Duck	11	22	03	24	26	18	32	37	21	24	17	35	46	47	46		52	29	06	-02	13	13	02	-00	04	-06	04	19	28	24
17. Grass Drill	05	31	00	17	13	18	14	34	09	25	17	30	36	39	47	52		28	14	04	16	09	05	04	-00	07	18	24	05	21
18. Soccer Dribble	-02	06	04	18	25	14	15	14	27	18	08	19	20	19	30	29	28		15	-06	11	10	10	-03	16	05	02	13	02	-03
19. 1-Ft. Length Bal. Eyes Op.	09	09	06	-03	15	11	05	01	18	25	22	19	04	06	11	06	14	15		16	47	23	27	06	24	14	21	32	24	16
20. 1-Ft. Length Bal. Eyes Cl.	10	-01	-02	-02	04	-01	12	01	03	-00	09	-01	-01	-04	02	-02	04	-06	16		13	46	29	44	21	13	33	13	00	-03
21. 1-Ft. Cross Bal. Eyes Op.	01	10	-07	03	13	01	15	05	05	18	16	26	06	14	11	13	16	11	47	13		34	47	32	23	08	26	37	11	25
22. 1-Ft. Cross Bal. Eyes Cl.	02	17	-09	06	14	15	26	16	18	21	07	17	04	13	19	13	09	10	23	46	34		24	28	32	17	20	39	09	09
23. 2-Ft. Cross Bal. Eyes Op.	-00	04	-01	11	11	01	18	08	09	08	13	10	10	03	04	02	05	10	27	29	47	24		47	18	04	32	12	16	11
24. 2-Ft. Cross Bal. Eyes Cl.	07	-00	-07	15	12	-03	14	08	05	04	09	-01	06	-06	-01	-00	04	-03	06	44	32	28	47		11	06	23	16	04	09
25. 2-Ft. Length Bal. Eyes Op.	-02	03	05	11	10	09	06	07	05	13	15	13	-04	-05	02	04	-00	16	24	21	23	32	18	11		30	10	24	05	22
26. 2-Ft. Length Bal. Eyes Cl.	-04	08	-09	03	11	09	17	13	06	19	17	16	04	20	03	-06	07	05	14	13	08	17	04	06	30		09	06	-01	13
27. Rail Walking	-05	10	06	12	12	21	13	-01	11	22	09	23	07	09	12	04	18	02	21	33	26	20	32	23	10	09		26	04	-01
28. Board Balance	09	09	-07	19	22	18	15	17	25	22	16	29	-08	17	14	10	14	18	32	13	37	39	12	16	24	06	26		13	06
29. Stick Balance	18	06	09	06	13	02	06	12	15	06	14	13	-08	10	08	24	05	02	24	00	11	02	16	04	05	-01	04	13		07
30. Ball Balance	13	10	06	02	04	-01	10	12	02	04	33	07	-03	13	-07	04	01	-03	10	-03	25	09	11	09	22	13	-01	06	07	

*Correlations are rounded to two places and decimals omitted.

TABLE 3

Centroid Factor Loadings*

	Tests	Factors					
		I	II	III	IV	V	VI
1.	Abdominal Stretch	18	-10	32	-24	30	18
2.	Toe Touch	35	07	26	-09	22	11
3.	Twist and Touch	-08	-05	25	-29	33	-08
4.	Squat, Twist and Touch	46	23	-21	-18	12	14
5.	Bend, Twist and Touch	50	17	-17	-17	06	12
6.	Lateral Bend	39	17	-22	-29	27	-10
7.	Plate Tapping	47	18	-16	21	-33	29
8.	Arm Circling	48	30	10	13	-14	31
9.	Block Transfer	42	-22	33	14	16	12
10.	One Foot Tapping	52	16	-15	-29	06	-10
11.	Two Foot Tapping	43	-10	13	-23	-13	23
12.	Leg Circling	52	17	-11	-12	-10	-19
13.	Dodge Run	40	-38	-20	-36	10	03
14.	Shuttle Run	53	-34	-21	-15	03	-13
15.	Circle Run	46	-35	-14	-19	-14	24
16.	Figure-8 Duck	54	-39	-25	-14	04	05
17.	Grass Drill	48	-30	-26	-19	-12	15
18.	Soccer Dribble	34	-20	05	04	10	17
19.	1-Ft. Lngth. Bal. Eyes Op.	41	-35	10	-16	-17	-34
20.	1-Ft. Lngth. Bal. Eyes Cl.	25	-45	-21	33	29	14
21.	1-Ft. Cross Bal. Eyes Op.	45	-40	03	12	-21	-23
22.	1-Ft. Cross Bal. Eyes Cl.	46	-29	-24	18	03	06
23.	2-Ft. Cross Bal. Eyes Op.	37	-40	-07	27	-03	-12
24.	2-Ft. Cross Bal. Eyes Op.	29	-39	-15	37	13	14
25.	2-Ft. Lngth. Bal. Eyes Op.	30	-33	-15	-16	-16	07
26.	2-Ft. Lngth Bal. Eyes Cl.	26	-08	-11	-04	-15	21
27.	Rail Walking	36	-21	-20	12	18	-23
28.	Board Balance	46	-17	-12	-05	-06	-10
29.	Stick Balance	24	-08	21	-11	-12	-11
30.	Ball Balance	21	-24	24	-15	-23	26

* Rounded to two places and decimals omitted.

TABLE 4

Rotated Factor Loadings*

	Tests	Factors**						h^2
		I ES	II GBE	III DF	IV B-V	V EF	VI SLM	
1.	Abdominal Stretch	04	03	01	01	55	15	33
2.	Toe Touch	28	06	12	02	39	12	26
3.	Twist and Touch	-03	-07	08	09	49	-10	27
4.	Squat, Twist and Touch	19	08	53	-10	11	17	38
5.	Bend, Twist and Touch	20	10	50	02	10	21	35
6.	Lateral Bend	07	06	58	00	21	-07	40
7.	Plate Tapping	39	16	23	-04	-30	44	52
8.	Arm Circling	52	04	18	-09	-01	39	46
9.	Block Transfer	15	01	56	13	-20	09	40
10.	One Foot Tapping	16	03	58	17	14	09	42
11.	Two Foot Tapping	11	05	19	19	20	46	34
12.	Leg Circling	27	03	48	26	-04	05	37
13.	Dodge Run	69	03	05	03	-11	04	49
14.	Shuttle Run	63	03	19	01	09	21	48
15.	Circle Run	59	06	24	11	08	-18	47
16.	Figure-8 Duck	68	04	21	12	07	08	53
17.	Grass Drill	62	06	16	12	15	-08	46
18.	Soccer Dribble	26	04	32	17	-07	-01	20
19.	1-Ft. Lngth. Bal. Eyes Op.	00	17	15	64	09	06	47
20.	1-Ft. Lngth. Bal. Eyes Cl.	-06	72	-03	-06	08	04	53
21.	1-Ft. Cross Bal. Eyes Op.	10	38	04	55	-07	13	48
22.	1-Ft. Cross Bal. Eyes Cl.	07	54	20	12	-05	17	39
23.	2-Ft. Cross Bal. Eyes Op.	08	53	00	32	-06	06	40
24.	2-Ft. Cross Bal. Eyes Cl.	05	64	-06	01	-02	12	43
25.	2-Ft. Lngth. Bal. Eyes Op.	-16	24	19	26	-01	31	28
26.	2-Ft. Lngth Bal. Eyes Cl.	02	13	15	03	05	33	15
27.	Rail Walking	05	44	24	20	02	-15	31
28.	Board Balance	08	27	30	29	01	13	27
29.	Stick Balance	12	-03	03	33	11	11	15
30.	Ball Balance	00	02	-10	22	14	47	30

* Rounded to two places and decimals omitte.

** The factors are identified as follows: I, Explosive Strength; II, Gross Body Equilibrium; III, Dynamic Flexibility; IV, Balance - Visual Cues; V, Extent Flexibility; VI, Speed of Limb Movement.

possibility that this factor might represent "agility" is ruled out by the absence of such tests as Squat, Twist and Touch or Bend, Twist and Touch. These latter tests also involve speed and so do other tests which do not load on this factor. Hence, there is no evidence here for a general speed factor. The presence of the Arm Circling and Two Plate Tapping tests extends the definition of this factor beyond a mere run or gross body propulsion factor. Further evidence on the interpretation of this factor comes from the previous study (Fleishman, Kremer, and Shoup, 1961). The Shuttle Run test is common to both studies, and its main loading in the previous study was on Explosive Strength or "Energy Mobilization." All short runs in the previous study were loaded on such a factor. This factor was defined as the ability to mobilize one's energy effectively in making single thrusting movements requiring a maximum expenditure of force. This apparently accounted for most of the variance in the running tests. Such an interpretation for the present factor would be consistent with the loading of Arm Circling and with the absence of certain other speed tests from this factor.

Factor II is defined by the balance tests involving maintenance of body

Test	Name	Loading
19	One Foot Lengthwise Balance - Eyes Closed	.72
26	Two Foot Cross Balance - Eyes Closed	.64
22	One Foot Cross Balance - Eyes Closed	.54
25	Two Foot Cross Balance - Eyes Open	.53
27	Rail Walking - Eyes Open	.44
21	One Foot Cross Balance - Eyes Open	.38

equilibrium. The sharp distinction between this factor and the others is indicated by the preponderance of zero loadings on this factor of all of the other (non-balance) tests. It is also of interest that the "performance balance" tests (balancing a ball or stick) do not load on this factor. The factor is measured by these tasks when the eyes are open as well as closed. However, it is best measured when the eyes are kept closed. In Table 4, it can be seen that for each separate test, the loading of the "eyes closed" condition is higher than that of the

"eyes open" condition. For some reason the Two Foot Lengthwise Balance tests and the One Foot Lengthwise Balance - Eyes Open test do not load highly on this factor. A possible reason might be in the order of administration. These tests were the first to be given in their series. For the present, this factor is labelled Gross Body Equilibrium.

Factor III is defined by tasks originally designed to measure Dynamic Flexibility as well as by certain other highly speeded tasks. An interesting feature of this factor is the absence of the three tests designed to measure "Extent Flexibility." Tests on the present factor emphasize both speed and flexibility of repeated trunk and/or limb movements. Apparently, the factor involves the ability to make repeated, rapid, flexing or stretching movements, where the extent of the movements is either short or long.

Test	Name	Loading
6	Lateral Bend	.58
10	One Foot Tapping	.58
9	Block Transfer	.56
4	Squat, Twist and Touch	.53
5	Bend, Twist and Touch	.50
12	Leg Circling	.48
18	Soccer Dribble	.32
28	Board Balance	.30

Factor IV is defined only by the balance tests given with the eyes open.

Test	Name	Loading
19	One Foot Lengthwise Balance - Eyes Open	.64
21	One Foot Cross Balance - Eyes Open	.55
29	Stick Balance	.33
23	Two Foot Cross Balance - Eyes Open	.32
28	Board Balance	.29

The indication is that such tests involve an additional ability which emphasizes the use of visual cues in maintaining balance. To differentiate this from Factor II, we will call this factor simply Balance - Visual Cues.

Factor V is confined to those tests included to define Extent Flexibility.

Test	Name	Loading
1	Abdominal Stretch	.55
3	Twist and Touch	.49
2	Toe Touching	.39

These three tests each require stretching of the trunk and back muscles as far as possible. The body is either stretched laterally, forward, or backward. No repeated or speeded flexing is required. This confirms the distinction between "Extent Flexibility" and "Dynamic Flexibility."

Factor VI is defined by three of the tests included to measure "Speed of Arm

Test	Name	Loading
30	Ball Balance	.47
11	Two Foot Tapping	.46
7	Plate Tapping	.44
8	Arm Circling	.39
26	Two Foot Lengthwise Balance - Eyes Closed	.33
25	Two Foot Lengthwise Balance - Eyes Open	.31

Movement" or "Speed of Leg Movement." It can be seen that arm and leg speed tests are on this factor. The explanation for the high loading of the Ball Balance test may be in the rapid adjustive arm movements which must be made to keep the ball from rolling off the arm. Similarly, the two balance tests do seem to require more rapid adjustive leg movements to maintain balance. In any case, this factor is renamed Speed of Limb Movement.

CONCLUSIONS

Six factors were identified to account for performance on the thirty performance tests. We had originally hypothesized nine factors and had allowed for the possibility of still additional factors. This finding is important in its own right since it provides for a simpler way of describing performance in these areas of physical proficiency.

Of the six factors identified, some conformed quite closely to those originally hypothesized (e.g. Extent and Dynamic Flexibility). Instead of separate "Speed of

Arm Movement" and "Speed of Leg Movement" factors, we have one factor common to both sets of limbs. We get separate Balance factors, as originally hypothesized, but they are somewhat different from our original conception of this area. The hypothesized "Speed of Change of Direction" factor did not emerge as a separate factor; rather, such performances were accounted for by an "Explosive Strength" factor previously identified. No separate "Agility" or "Coordination" factors were found. Rather, performances on tests thought to emphasize such factors were accounted for by the other factors identified (e.g. Explosive Strength, Dynamic Flexibility).

To summarize, the factors identified in the present study are as follows:

Explosive Strength - The ability to mobilize one's energy effectively in making single thrusting movements requiring a maximum expenditure of force. This is best measured in short run tests, such as Shuttle Run, as well as by the Broad Jump and Softball Throw tests.

Extent Flexibility - The ability to flex or stretch the trunk and back muscles as far as possible in either a forward, lateral, or backward direction. This is best measured by the Abdominal Stretch and Twist and Touch tests.

Dynamic Flexibility - The ability to make repeated, rapid, flexing movements. The resiliency of the muscles in recovering from strain or distortion seems critical here, since speed of these repeated movements is emphasized. The best measures include Lateral Bend and Squat, Twist and Touch.

Gross Body Equilibrium - The ability of an individual to maintain total body equilibrium, despite forces pulling him off balance, where he has to depend mainly on non-visual (e.g. vestibular and kinesthetic) cues. The factor is best measured by balance tests conducted with the eyes closed. However, the factor is general to balance tests where the eyes are kept open. Of course, these latter tests also involve vestibular and kinesthetic cues. Tests of this factor may be static tests (e.g. standing on one foot) or performance tests (e.g. rail walking). The best measure (highest

loading on this factor, zero loadings on other factors) of this factor was found to be One Foot Lengthwise Balance - Eyes Closed.

Balance - Visual Cues - The ability to maintain body balance, when visual cues are available. It is difficult to find a pure measure of this factor, since non-visual cues are also involved in such tasks. However, when the eyes are open this additional ability comes into play. The best measure appears to be One Foot Lengthwise Balance - Eyes Open.

Speed of Limb Movement - The speed with which an individual can make rapid ballistic or adjustive movements of arms or legs, when accuracy and force requirements are not involved. Good measures are Two Foot Tapping and Plate Tapping.

The Explosive Strength factor is the only factor which was found in our previous study of strength tests (Fleishman, Kremer, and Shoup, 1961). Its emergence in the present study extends the definition of this factor. The other five factors found here are additional to those found in the previous study. This previous study involved 33 entirely different tests (except for Shuttle Run which was common to both). These 33 tests were accounted for by four factors. Thus, it has been possible to "explain" performance in 62 different physical fitness tests in terms of ten factors. Furthermore, we have been able to specify the tests which seem to provide the best measures of each of these factors.

There are, of course, still many unanswered questions. One of the most intriguing concerns the nature of "coordination" and "agility." A concerted effort needs to be made to see if these are usefully considered "separate" abilities or if we can account for such performances in terms of the factors already identified. Thus far, these do not emerge as separate factors in our studies, but additional studies need to be carried out. These studies would involve a greater variety of "coordinated" performances than it has been possible to include so far. The use of our battery of factor tests, in the same study with these complex tests, should allow

us to specify how much of the variance in such performances we still need to explain.

Similarly, there is a need to use these factor tests to predict more complex skilled performances (e.g. athletic proficiencies). This would tell us what portion of such performances are specific to the individual skills and how much is relatable to the physical fitness factors identified in our present program. There is also the practical question of how valid our factor tests are in predicting performance in complex jobs involving physical skills.

We also need to know more about the trainability of these component abilities and the degree of transfer of training across tasks representing the same factor. We would expect high transfer between tests on the same factor and low transfer between factors. A more interesting question is the amount of transfer of training from these skill components to more complex skilled performances.

It also remains to combine the best measures of each factor into a more comprehensive battery of physical fitness tests. This, in fact, has already been done and research is underway to collect normative and comparative data on a national school sample as well as on cross-cultural samples. These results will be presented in subsequent reports in this series.

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